

CATALOG OF NARROW C IV ABSORPTION LINES IN BOSS (II): FOR QUASARS WITH $Z_{\text{EM}} > 2.4$

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ABSTRACT

As the second work in a series of papers aiming to detect absorption systems in the quasar spectra of the Baryon Oscillation Spectroscopic Survey, we continue the analysis of Paper I by expanding the quasar sample to those quasars with $z_{\text{em}} > 2.4$. This yields a sample of 21,963 appropriate quasars to search for narrow C IV $\lambda\lambda 1548, 1551$ absorptions with $W_r \geq 0.2 \text{ \AA}$ for both lines. There are 9708 quasars with at least one appropriate absorption system imprinted on their spectra. From these spectra, we detect 13,919 narrow C IV absorption systems whose absorption redshifts cover a range of $z_{\text{abs}} = 1.8784 - 4.3704$. In this paper and Paper I, we have selected 37,241 appropriate quasars with median $\text{SNR} \geq 4$ and $1.54 \lesssim z_{\text{em}} \lesssim 5.16$ to visually analyze narrow C IV $\lambda\lambda 1548, 1551$ absorption doublets one by one. A total of 15,999 quasars are found to have at least one appropriate absorption system imprinted on their spectra. From these 15,999 quasar spectra, we have detected 23,336 appropriate C IV $\lambda\lambda 1548, 1551$ absorption systems with $W_r \geq 0.2 \text{ \AA}$ whose absorption redshifts cover a range of $z_{\text{abs}} = 1.4544 - 4.3704$. The largest values of W_r are 3.19 \AA for the $\lambda 1548$ absorption line and 2.93 \AA for the $\lambda 1551$ absorption line, respectively. We find that only a few absorbers show large values of W_r . About 1.1% absorbers of the total absorbers have $W_r \lambda 1548 \geq 2.0 \text{ \AA}$.

Subject headings: quasars: absorption lines — quasars: general

1. INTRODUCTION

As we known, galaxies harbor reservoirs of gas know as the circumgalactic medium (CGM). The interactions between galaxies and their surrounding media involve the accretion of material that is required to maintain star formation and the dynamical mechanisms that influence the galactic environment, and move the heavy elements (metal-enriched gas) produced in the stars of galaxies from their places of production into galactic halos, the CGM, and the intergalactic medium (IGM; Veilleux et al. 2005; Fumagalli et al. 2011; Heckman et al. 2011). The latter role would enrich the material for future star formation. The two kinds of interactions are strongly affected by the galactic winds, filament infall, mergers, high velocity clouds, etc. (see Putman et al. 2012 for a review).

Due to the sensitivity of instruments, however, it is unrealistic to directly observe the fine structures and ingredients of the gaseous clouds harbored by the galaxies, especially for faint galaxies. Fortunately, absorption features are often detected in the spectra of distant objects when their sightlines go through the foreground (1) high velocity clouds, (2) IGM, (3) filament gas, (4) CGM, etc. These absorption features are a sensitive and unbiased tool for probing the gases of the universe from early periods (Meiksin 2009). Absorption features imprinted in the quasar spectra provide us with an excellent opportunity to investigate the gaseous content (e.g., densities, ionization structures, metallicities, temperatures, and kinematics) of extragalactic objects. These investigations do not depend on the luminosity and redshift of the corresponding quasar, or on the velocity and luminosity of the extra-galactic object which might otherwise be invisible. The destinies of the galaxies are ultimately connected to the fate of gas within them, and therefore studies of quasar absorption lines are helpful to our

understanding of the properties of galaxies (e.g., Zibetti et al. 2007; Ménard et al. 2011; Chen 2013; Burchett et al. 2013; Nielsen et al. 2013; Kacprzak et al. 2013).

Neutral- to high-ionization absorption lines have been observed in quasar spectra (e.g., Misawa et al. 2007; Tombesi et al. 2011; Chen et al. 2013a, 2013d; Chen & Qin 2013c; Gupta et al. 2013). These absorption features have historically been divided into three classes according to their line widths: (1) broad absorption lines (BALs) with line widths of no less than 2000 km s^{-1} at depths $> 10\%$ below the continuum, (2) narrow absorption lines (NALs) with line widths of less than a few hundred km s^{-1} , and (3) mini-BALs with intermediate line widths between those of BALs and NALs (e.g., Weymann et al. 1979; Rodríguez Hidalgo et al. 2011; Filiz Ak et al. 2012; Hamann et al. 2013).

Using the quasar spectra of the Sloan Digital Sky Survey (SDSS; York et al. 2000), many authors have conducted campaigns to systematically search for narrow metal absorption lines (e.g., Quider et al. 2011; Qin et al. 2013; Zhu & Ménard 2013; Cooksey et al. 2013; Seyffert et al. 2013). The SDSS program continued with the Third SDSS (SDSS-III) using the same 2.5 m telescope (Gunn et al. 2006; Rossetal. 2012). This program collected data from 2008 to 2014. The Baryon Oscillation Spectroscopic Survey (BOSS) is the main dark time legacy survey of SDSS-III (Pâris et al. 2012), which has obtained more than 150,000 quasar spectra with $z_{\text{em}} > 2.15$ during its five year run time. The BOSS spectrograph has a wavelength range of $3600 \text{ \AA} - 10400 \text{ \AA}$ at a resolution of $1300 < R < 3000$. The SDSS Data Release Nine (SDSS-DR9), which is the first spectral data release of BOSS to the public, includes 87,822 quasars detected over an area of 3275 deg^2 (Pâris et al. 2012).

This paper is the second part in a series aiming to analyze absorption lines in the BOSS quasar spectra. We intend to search for narrow absorption doublets (e.g., Mg II $\lambda\lambda 2796, 2803$, and C IV $\lambda\lambda 1548, 1551$) in the BOSS quasar spectra. In the first paper, Chen et al. (2014a, 2014b; hereafter, the two papers are referred to as Paper I), we fo-

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cused on narrow C IV absorption doublets. Paper I concerned those quasars with $z_{\text{em}} \leq 2.4$ and a high signal-to-noise ratio (S/N) for their spectra. These criteria limit the detection to 15,278 appropriate quasars for the detection of narrow C IV absorption features. Of these 15,278 quasars, 6291 quasars are observed to host C IV absorption system(s). In Paper I, we obtained a catalog of 9417 narrow C IV systems with $z_{\text{abs}} = 1.4544 - 2.2805$.

This work continues the detection of Paper I by expanding the quasar sample to those quasars with $z_{\text{em}} > 2.4$ to search for narrow C IV absorption doublets in the BOSS quasar spectra.

We describe our data analysis in Section 2 and present the statistical properties of absorptions in Section 3. The summary is presented in Section 4.

2. DATA ANALYSIS

This work continues the analysis of Paper I by expanding the quasar sample to those quasars with $z_{\text{em}} > 2.4$. We adopt the same methods to construct quasar samples and detect narrow C IV $\lambda\lambda 1548, 1551$ doublets. Here, we simply summarize the main steps involved in the quasar selection and absorption line detection procedures. Readers can refer to Paper I for more details.

In order to avoid the confusions from Ly α , O I $\lambda 1302$ and S II $\lambda 1304$ absorptions and the noisy region of the spectra, the spectra regions shortward of 1310 Å in the rest frame or shortward of 3800 Å in the observed frame are not considered. In addition, to detect as much of the intervening C iv absorption doublets as possible, we constrain our analysis to the data range within 10,000 km s⁻¹ blueward of the quasar system. These cuts reduce the number of SDSS DR9 quasars from 87,822 to 70,336.

Each quasar spectrum has a value of the median S/N (median S/N). Based on the median value of the median S/N of these 70,336 quasars, median median $\text{SNR} \geq 4$ is adopted to alleviate the noise confusion superposed on the spectra with low values of S/N. This further reduces the number of quasar samples from 70,336 to 37,241.

As a continuation of the work of Paper I, here we only concern ourselves with high-redshift quasars with $z_{\text{em}} > 2.4$. Considering all of the above limitations, we obtain 21,963 appropriate quasars. Figure 1 shows the limits of the median S/N and the redshift. The emission redshift distribution of 21,963 quasars is shown by the red line in Figure 2.

For each quasar, a combination of the cubic spline function and Gaussian functions was invoked to derive a pseudo-continuum in an iterative fashion (e.g., Nestor et al. 2005; Chen et al. 2013a, 2013d, 2013b; Chen & Qin 2013c). C iv absorption doublets were detected on the pseudo-continuum fitting normalized spectra. There are several steps in this detection. First, we label the 2σ flux uncertainty level and get rid of the absorption troughs above this level. Second, BALs are disregarded by the program searching for candidate absorptions. Third, in this program, a Gaussian function is adopted to fit each absorption feature, while the absorption figures with FWHM greater than 800 km s⁻¹ are ignored. Fourth, measurements of the equivalent widths at rest-frame (W_r) of the candidate absorptions are based on the Gaussian fittings, and estimations of their flux uncertainties are performed via

$$(1+z)\sigma_w = \frac{\sqrt{\sum_i P^2(\lambda_i - \lambda_0) \sigma_{f_i}^2}}{\sum_i P^2(\lambda_i - \lambda_0)} \Delta\lambda, \quad (1)$$

where, as a function of pixel, $P(\lambda_i - \lambda_0)$, λ_i and σ_{f_i} are the

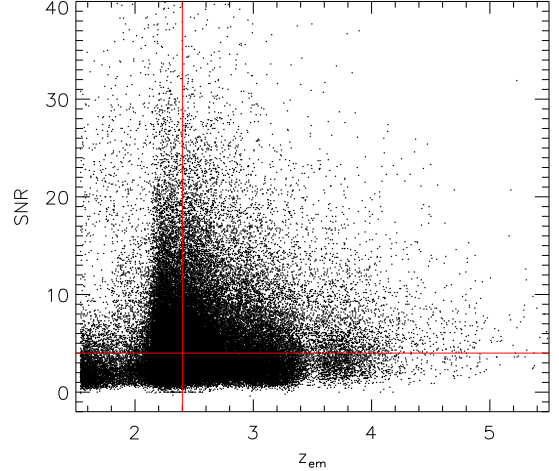


FIG. 1.— Plot of the median S/N vs. the emission redshift. The horizontal red line stands for $S/N = 4$ and the vertical red line stands for $z_{\text{em}} = 2.4$, which are used to construct quasar samples. Paper I contained quasars with $\text{SNR} \geq 4$ and $z_{\text{em}} \leq 2.4$. In this paper, we detect C iv absorption on the spectra of the quasars with $\text{SNR} \geq 4$ and $z_{\text{em}} > 2.4$.

line profile centered at λ_0 , the wavelength, and the normalized flux uncertainty, respectively. The signal-to-noise ratio of candidate absorption lines is estimated using the same method adopted by Qin et al. (2013). The value of 1σ noise is computed via:

$$\sigma_N = \sqrt{\frac{\sum_{i=1}^M \left[\frac{F_{\text{noise}}^i}{F_{\text{cont}}} \right]^2}{M}}, \quad (2)$$

where F_{noise} , F_{cont} , and i are the flux uncertainty, the flux of the pseudo-continuum fitting, the pixel in the wavelength range of $1548\text{Å} \times (1 + z_{\text{abs}}) - 5\text{Å} < \lambda_{\text{obs}} < 1551\text{Å} \times (1 + z_{\text{abs}}) + 5\text{Å}$, respectively. Based on the value determined by formula (2), we can obtain the signal-to-noise ratio of the candidate absorption line via

$$\text{SNR}^\lambda = \frac{1 - S_{\text{abs}}}{\sigma_N}, \quad (3)$$

where S_{abs} is the largest depth within an absorption trough with respect to the pseudo-continuum fitting in the normalized spectra. Fifthly, all absorption features with $W_r > 0.2$ Å and $\text{SNR}^\lambda \geq 2.0$ for both lines of the doublet are kept in the catalog.

Using the same method as in Paper I, we find that 9708 quasars from the quasar sample (containing 21,963 quasars) host narrow C iv absorption system(s). From these 9708 quasar spectra, we obtain 13,919 potential intervening C iv absorption systems. The absorption data are provided in Table 1.

3. STATISTICAL PROPERTIES OF THE ABSORBERS

3.1. Properties of the absorbers in catalog (II)

This paper is the second in a series on the analysis of absorption lines in the quasar spectra of BOSS, which expands the quasar sample to quasars with $z_{\text{em}} > 2.4$. 21,963 appropriate quasars are adopted to search for narrow C IV $\lambda\lambda 1548, 1551$ absorption doublets. Among these, 9708 quasars are observed to host appropriate C iv absorption feature imprinted on their spectra. The distributions of the emission redshifts of the 21,963 quasars and the 9708 quasars are shown in Figure 2. In the 9708 quasar spectra, we detect

TABLE 1
CATALOG OF C IV $\lambda\lambda 1548, 1551$ ABSORPTION SYSTEMS

SDSS NAME	PLATEID	MJD	FIBERID	z_{em}	z_{abs}	$W_r\lambda 1548$	$N_{\sigma\lambda 1548}$	$W_r\lambda 1551$	$N_{\sigma\lambda 1551}$	$SNR^{\lambda 1548}$	$SNR^{\lambda 1551}$	β
000014.07+012951.5	4296	55499	0370	3.2284	2.6728	0.70	4.38	0.68	4.00	4.2	3.8	0.13994
000015.17+004833.2	4216	55477	0718	3.0277	2.5222	1.11	6.94	0.84	7.64	6.4	7.1	0.13331
000027.31+013126.1	4296	55499	0382	2.5892	2.3169	0.35	4.38	0.37	4.63	3.9	4.1	0.07874
000041.87-001207.2	4216	55477	0274	3.0514	2.6206	0.37	6.17	0.42	5.25	6.0	4.9	0.11195
000041.87-001207.2	4216	55477	0274	3.0514	2.6600	0.83	5.93	0.30	3.33	5.6	3.2	0.10125
000046.42+011420.8	4216	55477	0742	3.7588	3.1522	1.50	8.33	1.39	8.69	7.9	8.2	0.13552
000046.42+011420.8	4216	55477	0742	3.7588	3.1777	1.39	9.93	1.09	8.38	9.4	7.7	0.12950
000051.56+001202.5	4216	55477	0778	3.8953	3.3315	1.18	4.54	1.19	4.76	4.3	4.5	0.12175
000051.56+001202.5	4216	55477	0778	3.8953	3.3721	2.43	9.00	2.87	10.63	8.5	10.0	0.11255
000057.58+010658.6	4216	55477	0750	2.5493	2.0827	0.48	4.36	0.80	8.00	4.1	7.7	0.14002

Note— $N_{\sigma} = \frac{W_r}{\sigma_w}$ represents the significant level of the detection. $\beta = v/c = ((1+z_{em})^2 - (1+z_{abs})^2)/((1+z_{em})^2 + (1+z_{abs})^2)$.

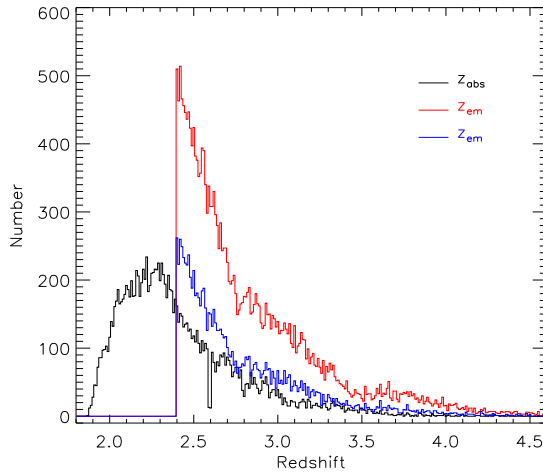


FIG. 2.— Distributions of redshifts for catalog II. The red line represents the distribution of the emission redshift of the 21,963 quasars used to detect C iv absorption systems, and the blue line is for that of the 9708 quasars detected with C iv absorptions. The black line represents the distribution of the redshift of the C iv absorption doublets.

13,919 narrow C IV $\lambda\lambda 1548, 1551$ absorption doublets with $1.8784 \leq z_{abs} \leq 4.3704$, and the distribution of these absorption redshifts are also shown in Figure 2. (Note that these absorption doublets only refer to catalog II, and those contained in Paper I only refer to catalog I.)

In Figure 3, we plot the total redshift path covered by the absorbers of catalog II as a function of the S/N of the absorption features, which is calculated by

$$Z(SNR^{\lambda 1548}) = \sum_{i=1}^{N_{spec}} \int_{z_i^{min}}^{z_i^{max}} g_i(SNR^{\lambda 1548}, z) dz, \quad (4)$$

where z_i^{max} and z_i^{min} are the redshifts corresponding to the maximum and minimum wavelengths in the survey spectral region of quasar i , respectively; $g_i(SNR^{\lambda 1548}, z) = 1$ if $SNR^{lim} \leq SNR^{\lambda 1548}$, otherwise $g_i(SNR^{\lambda 1548}, z) = 0$ (see also Qin et al. 2013; Paper 1).

In Figure 4, we show the W_r distributions of detected C IV $\lambda\lambda 1548, 1551$ absorption doublets in catalog II, which are similar to those in catalog I. Smooth tails out to $W_r \approx 3.0$ Å can clearly be seen in these distributions. The largest and median values of $W_r\lambda 1548$ are 2.95 Å and 0.60 Å respectively, and those of $W_r\lambda 1551$ are 2.93 Å and 0.47 Å respectively. In catalog II, only a few absorbers with large W_r are de-

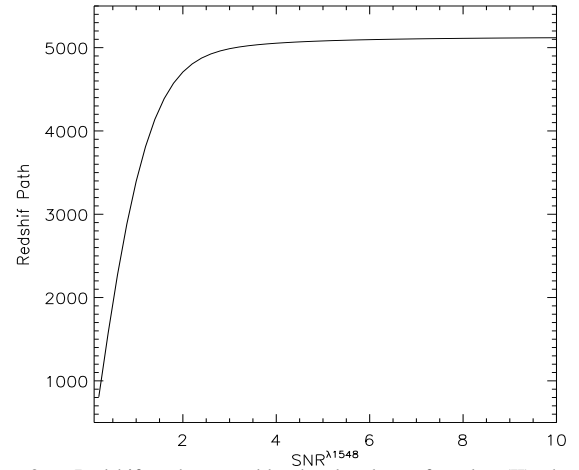


FIG. 3.— Redshift path covered by the absorbers of catalog (II), shown as a function of $SNR^{\lambda 1548}$.

tected, with only 1.0% (137/13919) and 16.9% (2349/13919) absorbers of the total having $W_r\lambda 1548 \geq 2.0$ Å and 1.0 Å $\leq W_r\lambda 1548 < 2.0$ Å, respectively. Most absorbers show small or medium values of absorption strengths, with about 47.2% (6564/13919) and 35.0% (4869/13919) absorbers of the total having 0.5 Å $\leq W_r\lambda 1548 < 1.0$ Å and 0.2 Å $\leq W_r\lambda 1548 < 0.5$ Å, respectively. These proportions are similar to those in Paper I.

The saturated degree of absorptions can be evaluated by the W_r ratio (DR ; Strömberg 1948). Theoretical values of DR of the C IV $\lambda\lambda 1548, 1551$ resonant doublet can vary from 1.0 for completely saturated absorption to 2.0 for completely unsaturated absorption (e.g., Sargent et al. 1988). In Figure 5, we show the DR of the C IV $\lambda\lambda 1548, 1551$ resonant doublet ($W_r\lambda 1548/W_r\lambda 1551$) in catalog (II) where the theoretical boundaries of the completely unsaturated absorption and completely saturated absorption are plotted with red dash lines. A maximum value (4.7) of the DR and a minimum value (0.2) can be seen from the Figure. There are about 20.4% (2844/13919) and 7.1% (993/13919) absorbers with $DR < 1.0$ and $DR > 2.0$, respectively. Meanwhile, there are about 72.4% (10082/13919) absorbers with $1.0 \leq DR \leq 2.0$. These proportions are similar to those in Paper I. Some narrow absorption features cannot be resolved by a low-/middle-resolution spectrograph, which may result in blending of narrow absorption features. BOSS spectra have a resolution of $1300 < R < 3000$. These low-/middle-resolution spectra can lead to some very narrow C iv absorptions suffering from

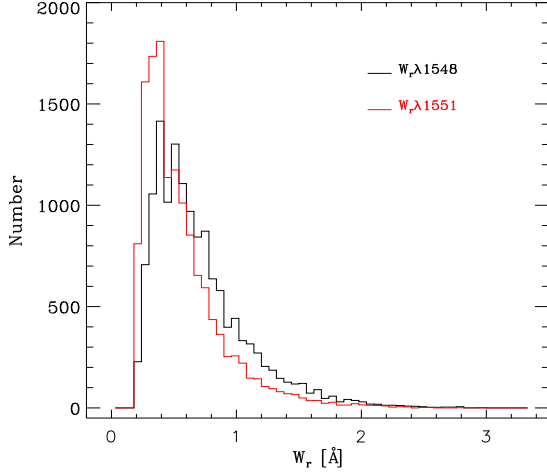


FIG. 4.— Distributions of the W_r of the C IV absorption lines detected in catalog (II). The black line stands for the $\lambda 1548$ absorptions, and the red line stands for the $\lambda 1551$ absorptions.

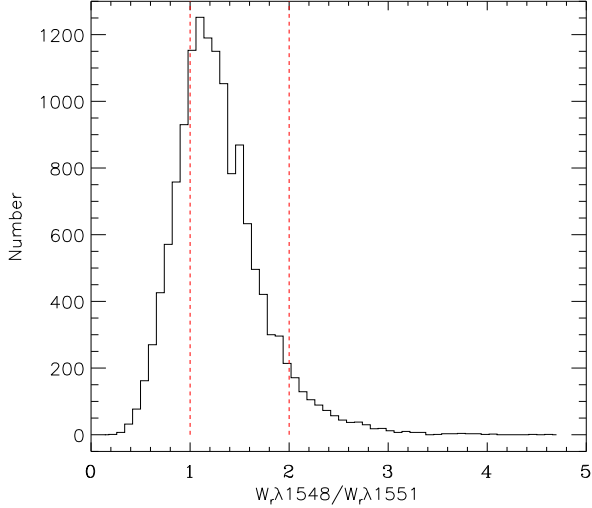


FIG. 5.— Distribution of the W_r ratio of the C IV doublets in catalog (II). The red dash lines are the theoretical boundaries of completely saturated ($W_r\lambda 1548/W_r\lambda 1551 = 1.0$) and unsaturated ($W_r\lambda 1548/W_r\lambda 1551 = 2.0$) absorptions, respectively.

blending with unrelated absorption features. The “false positive” lines, which happen to have the same separation as the two lines of the C iv doublet but essentially no relation to each other, may confuse the identification of the C iv absorption doublet. We guess that line blending and this kind of “false positive” line would be the main reason accounting for the fact that about a quarter of the narrow C iv systems lie outside the theoretical limits of the W_r ratio. This conjecture could be checked by Monte Carlo simulations. That is an interesting issue that deserves a detailed investigation, and we intend to do so in a later paper.

We calculate the frequency of detected C IV absorption doublets (f_{NALs}) to give an expression to the false positives/negatives of C IV absorption doublets as follow

$$f_{\text{NALs}} = \lim_{\Delta \text{SNR} \rightarrow 0} \frac{\Delta N_{\text{abs}}}{\Delta N_{\text{sdp}}} \quad (5)$$

where ΔN_{abs} is the number of detected C IV absorption doublets, and ΔN_{sdp} is the number of data points in signal-to-

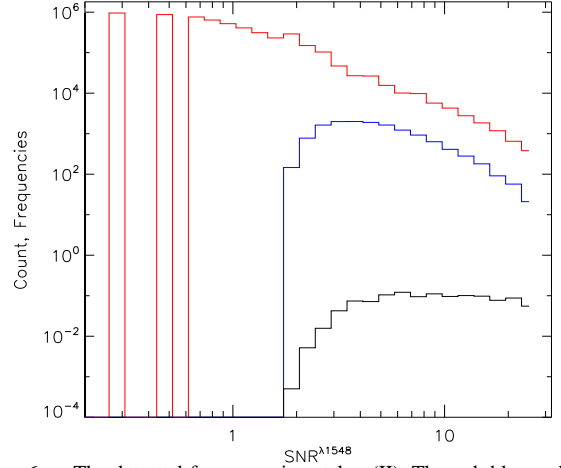


FIG. 6.— The detected frequency in catalog (II). The red, blue and black lines represent the number of data points, number of detected C IV absorptions, and frequency of NALs in catalog (II), respectively.

TABLE 2
THE MISSING RATE OF ABSORPTION SYSTEMS WITH $\text{SNR}^{\lambda 1548} \leq 4$

SNR bin	[2.0,2.5]	[2.5,3.0]	[3.0,3.5]	[3.5,4.0]
f_{MR}	0.88	0.56	0.53	0.07

noise ratio bin ΔSNR . The deriving f_{NALs} is shown in Figure 6. It clearly shows a smooth distribution of the f_{NALs} in the range of $\text{SNR}^{\lambda 1548} \gtrsim 4$, which implies a completed detection when the signal-to-noise ratio is larger than 4. This is similar to that in Paper 1.

Figure 6 also suggests a significant incomplete detection when $\text{SNR}^{\lambda 1548} \lesssim 4$, whose missing rate (f_{MR}) can be evaluated in several bins of the signal-to-noise ratio by

$$f_{\text{MR}} = \frac{\overline{f_{\text{NALs}}} - f_{\text{NALs}}}{\overline{f_{\text{NALs}}}}, \quad (6)$$

where $\overline{f_{\text{NALs}}}$ and f_{NALs} are the average frequency of NALs in the range of $\text{SNR}^{\lambda 1548} > 4$, and the frequency of NALs in the corresponding signal-to-noise ratio bin, respectively. The results are provided in Table 2.

3.2. Properties of the absorbers in catalogs (I - II)

As the first two papers in a series concerned with searching absorption lines in the BOSS quasar spectra, we have collected a sample of 37,241 appropriate quasars with median $\text{SNR} \geq 4$ and $1.54 \lesssim z_{\text{em}} \lesssim 5.16$ to detect potential intervening C IV $\lambda\lambda 1548, 1551$ absorptions. From the quasar sample, we have found 15,999 quasars with at least one appropriate C IV $\lambda\lambda 1548, 1551$ absorption doublets imprinted on their spectra. From these 15,999 quasar spectra, we have detected 23,336 narrow C IV $\lambda\lambda 1548, 1551$ absorption systems with $z_{\text{abs}} = 1.4544 - 4.3704$. Shown In Figure 7, we display distributions of emission redshifts of the 37,241 quasars and the 15,999 quasars, as well as the absorption redshifts of the 23,336 absorbers.

The redshift path of catalogs I and II is calculated using formula (4) as well. The result is plotted in Figure 8 where the redshift paths covered by catalogs I and II are also shown with dot-dashed and dashed lines, respectively.

The W_r distributions are plotted in Figure 9, which show tails up to $W_r \approx 3 \text{ Å}$. The largest and median absorption strengths of $\lambda 1548$ lines are $W_r\lambda 1548 = 3.19 \text{ Å}$ and 0.61

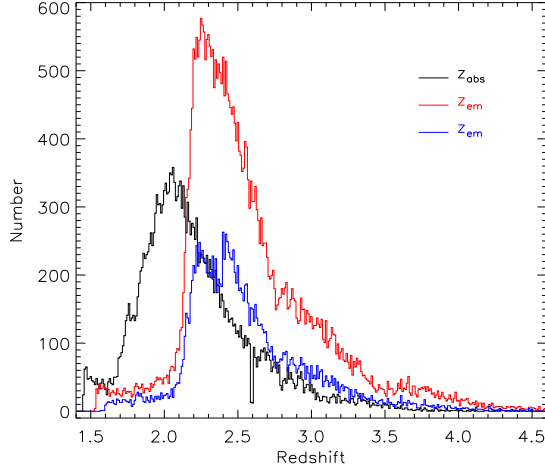


FIG. 7.— Distributions of redshifts included in catalogs (I - II). See Figure 2 for the meanings of the lines.

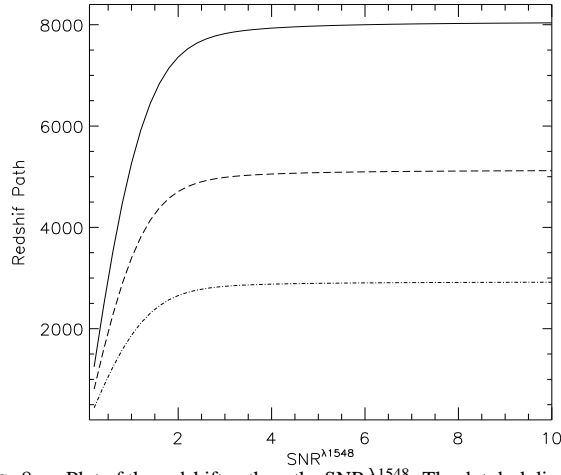


FIG. 8.— Plot of the redshift path vs the $SNR^{\lambda 1548}$. The dot dash line is for that of catalog (I); the dash line is for that of catalog (II); and the solid line is the sum of that of these two catalogs.

\AA , respectively, and those of $\lambda 1551$ are $W_r \lambda 1551 = 2.93 \text{ \AA}$ and 0.48 \AA , respectively. We find that, in catalogs (I - II), there are a few absorbers with large W_r , namely, only 1.1% (249/23336) and 17.8% (4124/23336) absorbers of the total with $W_r \lambda 1548 \geq 2.0 \text{ \AA}$ and $1.0 \text{ \AA} \leq W_r \lambda 1548 < 2.0 \text{ \AA}$, respectively. Most of the absorbers show small or middle values of absorption strengths. That is, there are about 46.6% (10879/23336) and 34.6% (8084/23336) absorbers of the total with $0.5 \text{ \AA} \leq W_r \lambda 1548 < 1.0 \text{ \AA}$ and $0.2 \text{ \AA} \leq W_r \lambda 1548 < 0.5 \text{ \AA}$, respectively.

The distribution of the W_r ratio is displayed in Figure 10. The W_r ratio has a maximum value of 4.7, and has a minimum value of 0.2. There are about 21.2% (4958/23336) and 6.7% (1565/23336) absorbers with $DR < 1.0$ and $DR > 2.0$ respectively. And there are about 72.1% (16813/23336) absorbers with $1.0 \leq DR \leq 2.0$.

The detected frequency of C IV absorptions is calculated using formula (5). The deriving result is plotted in Figure 11, where the distributions of f_{NALS} obtained from catalogs (I) and (II) are displayed with dot dash and dash lines, respectively. Smooth curves are the distributions of f_{NALS} with $SNR^{\lambda 1548} \gtrsim 4$.

We estimate the missing rate of absorption systems with

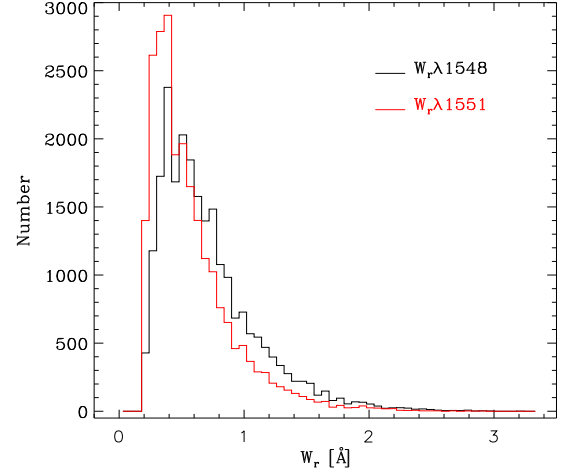


FIG. 9.— Distributions of W_r of C IV absorptions that are included in catalogs (I - II). The black and red lines represent the $\lambda 1548$ and $\lambda 1551$ absorptions, respectively.

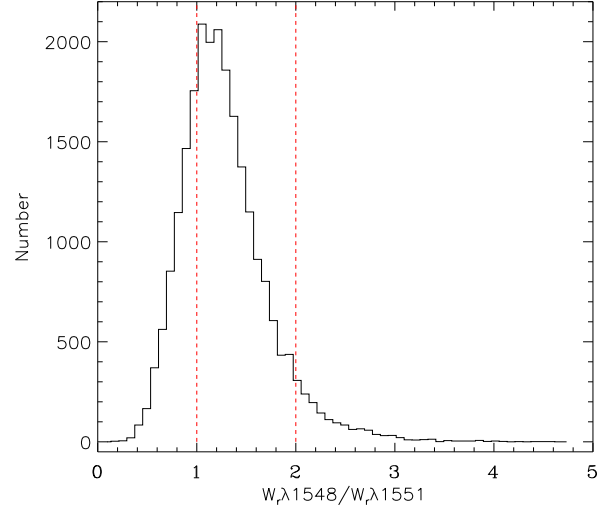


FIG. 10.— Distribution of the W_r ratios of the C IV doublets in catalogs (I - II) (the solid line). See Figure 5 for the meanings of other lines.

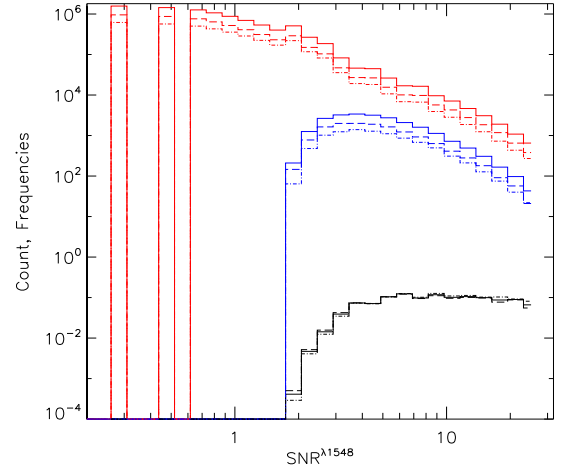


FIG. 11.— The detection frequency vs the signal-to-noise ratio. See Figure 6 for meanings of color lines. The dot dash line is for those of catalog (I); the dash line is for those of catalog (II); and the solid line is for those of the sum of the two catalogs.

TABLE 3
THE MISSING RATE OF ABSORPTION SYSTEMS WITH $SNR^{\lambda 1548} \leq 4$

SNR bin	[2.0,2.5]	[2.5,3.0]	[3.0,3.5]	[3.5,4.0]
f_{MR}	0.91	0.68	0.62	0.20

$SNR^{\lambda 1548} \leq 4$ in several bins of the signal-to-noise ratio using formula (6). The deriving results are provided in Table 3.

4. SUMMARY

This paper continues the work of Paper I aiming to detect absorption lines by expanding the quasar sample to those quasars with $z_{em} > 2.4$. This sample contains 21,963 quasars, of which 9708 quasars have at least one potential intervening C IV $\lambda\lambda 1548, 1551$ absorption systems with $W_r \geq 0.2$ Å for both lines. From these quasar spectra, we have detected 13,919 appropriate C IV $\lambda\lambda 1548, 1551$ absorption systems with $z_{abs} = 1.8784 - 4.3704$. About 35.0%, 47.2%, 16.9%, and 1.0% absorbers of the total have $W_r \lambda 1548 = 0.2 - 0.5$ Å, $W_r \lambda 1548 = 0.5 - 1.0$ Å, $W_r \lambda 1548 = 1.0 - 2.0$ Å, and $W_r \lambda 1548 \geq 2.0$ Å, respectively.

The absorption doublets detected in this paper refer to catalog II, and those from Paper I refer to catalog I. Catalogs I and II contain a total of 15,999 quasars that have been detected as hosting appropriate C iv absorptions imprinted on their spectra. These quasars are selected from a sample of 70,336 quasars in the limit of median $SNR \geq 4$. From these quasar spectra, we have detected 23,336 narrow C iv absorption systems with $z_{abs} = 1.4544 - 4.3704$. The largest absorption strengths are 3.19 Å and 2.93 Å for the $\lambda 1548$ and $\lambda 1551$ lines, respectively. Only a few absorbers show large values of W_r , with most of the absorbers having small or middle values of W_r . There are about 34.6%, 46.6%, 17.8%, and 1.1% absorbers of the total with $W_r \lambda 1548 = 0.2 - 0.5$

Å, $W_r \lambda 1548 = 0.5 - 1.0$ Å, $W_r \lambda 1548 = 1.0 - 2.0$ Å, and $W_r \lambda 1548 \geq 2.0$ Å, respectively.

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